DOCUMENT RESUME

ED 426 184 CE 076 797

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TITLE	Linking VET to Productivity Differences: An Evaluation of the Prais Program, and its Implications for Australia. Working Paper No. 18.
INSTITUTION	Monash Univ., Clayton, Victoria (Australia). Centre for the Economics of Education and Training.
SPONS AGENCY	Australian National Training Authority, Brisbane.
PUB DATE	1998-02-00
NOTE	39p.
PUB TYPE	Reports - Evaluative (142)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Comparative Analysis; *Educational Benefits; Educational Certificates; *Foreign Countries; *Job Skills; Manufacturing Industry; Postsecondary Education; *Productivity; Secondary Education; Student Certification; *Vocational Education
IDENTIFIERS	Australia; France; Germany; *Great Britain; Netherlands

ABSTRACT

Research tested the hypothesis that preemployment vocational education is a major contributor to enterprise productivity, because it raises workers' skills that are then applied in more effective work practices. An intercountry comparisons approach involving Britain and Germany and Britain and the Netherlands or France identified medium-sized establishments that produced similar products and compared and contrasted the following: worker productivity; management styles and practices; technologies used; workplace organization; on-the-job training; level and type of vocational qualifications of workers; and curriculum content relating to the qualifications. Findings were as follows: the average productivity of the British enterprises was below that of their counterparts; percentages of British personnel holding intermediate qualifications were much lower; in contrast to British manufacturing, German manufacturing was withdrawing from producing bulk quantities of standard goods; German companies were more inclined to use numerically controlled machinery; and machine breakdowns were rare in Germany, but common in Britain. The different productivity levels were also due to workers' capabilities, which could be explained as a consequence of differences in work preparation. Implications for Australia were to emphasize skilling to increase productivity in customized, high-quality products; to develop technological competence; and to implement rigorous student assessment. (Contains 46 references.) (YLB)

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CEET

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Leo Maglen and Sonnie Hopkins

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The Centre for the Economics of Education and Training is funded by the Commonwealth Government through the Australian National Training Authority as a Key Vocational Education and Training Research Centre.

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The *Monash University-ACER Centre for the Economics of Education and Training (CEET)* is a joint venture of Monash University and the Australian Council for Educational Research now in collaboration with the Department of Vocational Education and Training (DVET) at the University of Melbourne.

The Centre is managed by four Co-Directors:

- Gerald Burke (Associate Professor, Faculty of Education, Monash University, Executive Director);
- Phillip McKenzie (Principal Research Fellow, ACER, currently on secondment to the OECD, Paris - John Ainley, Associate Director ACER, Acting Co-Director);
- Leo Maglen (Professor and Head of Department of Vocational Education and Training, University of Melbourne); and
- Chris Selby Smith (Professor, Department of Management, Monash University).

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Focus of Work

CEET's research focuses on the contribution of education and training to economic and social development and the implications of economic change for education and training. Much of the research is concerned with improving the knowledge base for policy development and implementation. The Centre seeks advice from its VET Advisory Committee which includes members from the Business Council of Australia, ACE, private registered training organisations, TAFE institutes, ANTA and members of state training authorities. CEET is located in Melbourne but is engaged in projects across Australia.

Funding

CEET receives its main funding from ANTA, having been selected in 1994 as a key national VET Research Centre. Recent studies have been funded by the Australian Research Council, the Department of Employment, Education, Training and Youth Affairs, the Office of Training and Further Education Victoria, the Organisation for Economic Cooperation and Development and the National Centre for Vocational Education Research Ltd.

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Working Paper

LINKING VET TO PRODUCTIVITY DIFFERENCES:
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Leo Maglen and Sonnie Hopkins

February 1998

This working paper relates to a research project undertaken at the Department of Vocational Education and Training within the Faculty of Education, University of Melbourne, in association with the Centre for the Economics of Education and Training. A version of the paper was presented at the AVETRA Conference, February, 1998, under the title, **VET and Productivity: Some possible lessons for Australia**.

1. INTRODUCTION

Vocational eduction has a crucial role in the Government's vision to develop Australia as a society able to adapt flexibly and dynamically to the changes of a highly competitive global economy.

The Hon. Dr David Kemp MHR
Minister for Schools, Vocational Education and Training
In Australia Training
Volume 4 (1) 199 7 p. 9

Assumptions regarding VET and Productivity

More and more critical to whether people are able to secure and to retain employment, are assessments of the contributions they are able to make to the continued viability of the organisations that employ them. In the private sector, continued viability means continued profitability, and that depends upon how competitive enterprises can remain. That in turn depends to a large extent on how productively and cost-effectively they can deploy the inputs of their labourforces, their management teams, their plant, equipment and supplies, and so on, to meet the requirements of their markets in terms of price, quality, backup services and whatever.

The contribution of workers is increasingly seen in terms of their flexibility in the face of changing commercial circumstances, as much as in the quantity and quality of the output they can produce. That is, it is seen in their adaptability to new technology and altered work practices; their mobility, willingness and capacity to perform new tasks and to take on new responsibilities; and their ability to demonstrate initiative, teamwork, leadership, etc. Reliable means of assessing worker performance overall, and in all of these dimensions, are correspondingly becoming more and more important, not only to employers in their recruiting and labour management strategies, but to those who are interested in finding out what are the major contributing factors to improved worker performance.

The basic standard measure of overall worker performance employed by economists in their studies of enterprises, industries and economies has been *average labour productivity* – in simple terms, the physical output of an enterprise, industry or economy in a given time period, divided by the number of workers employed in that period in that enterprise, industry or economy. Variations on the measure are also used (the most important of which is *marginal productivity of labour*), and considerable refinement is usually required to measure it in practice; but essentially this is what is commonly meant by the term "productivity". Thus, productivity of workers is said to be higher when output per worker is greater, or when the labour content of a unit of output is lower.

Though a range of factors can contribute to the level of and changes in average labour productivity, many of these are structural and technological, over which workers have little control. Labour productivity tends to be higher in capital-intensive production processes than in labour-intensive ones, simply because plant and machinery contribute a

larger share of the resulting output. As processes become more automated, leaner and more streamlined, with inevitable reductions in the numbers employed, the workers that are still on the payroll, perforce, will be more 'productive' by this definition. Whilst these remaining jobs may have been extensively re-designed, and those who fill them may be required to perform a different, broader, set of tasks, there may be no appreciable change in the *level* of skills needed, nor in how hard, or smart, those holding the jobs are required to work.

What difference education and training make to worker productivity is an old question, but one for which there is no easy answer. Mostly it is taken as self-evident that the role of education, and especially vocational education and training, is a significant, even a decisive one. After all, its whole rationale is that it provides the skills, knowledge, competencies and capabilities people require to successfully enter, and be retained in, gainful employment. In many quarters the connection is taken for granted, with the consequence that there is surprisingly little systematic enquiry into how, and by how much, vocational education and training actually increase worker productivity. Far greater attention is given to how vocational education and training are organised and delivered, than to their impact upon worker performance and productivity.

Economists have contributed to this complacency. It is one of the most widespread of observations in the world of human affairs, that workers with more education tend, on average, to earn more than those with less. The standard economic explanation is that they are more productive, since in a market-oriented economy employers are required to pay more productive workers a greater amount than less productive workers, if they want both to attract and retain them. The more competitive the labour-markets are, the more accurately earnings differences will reflect productivity differences. For economists, therefore, it is customary to use observations of the former as measures of the latter. It is not within the scope of this paper to question the appropriateness of this approach – that has been done elsewhere - see, for example, Maglen (1990 and 1993). Suffice to say, that serious reservations can be held concerning the theoretical and empirical bases of the education-earnings-productivity linkages, and that alternative explanations can be advanced for the education-earnings association that do not necessarily imply a link with productivity differences.

Problems of Demonstration

All of which brings us back to the challenge of direct observation of education-productivity linkages. One of the biggest, and most obvious, difficulties associated with trying to find out whether more educated and trained workers are more productive than less educated and trained workers, is that they are generally not in situations where direct comparisons can be made. This is because people with different amounts of education and training usually do not work in the same jobs, in the same production processes. People with different amounts and types of education and training tend to go into different occupations, in different enterprises, industries and locations, where the production processes may bear little similarity. Comparing productivity differences in these circumstances is often not possible because the benchmarks are not the same. In

what sense is a physician more productive than a schoolteacher, or a plumber less productive than an information technologist?

Valid comparisons of productivity differences can only really be made when, as much as possible, like is compared with like, and where as many other factors as possible are being controlled for. This paper reviews an important long-term research program that has attempted to do this with the use of micro-level international comparative studies. It has been undertaken at the National Institute of Economics and Social Research in Britain and has employed micro studies to examine the relationship between vocational education and productivity. The National Institute has collaborated with other organisations and in particular, the Technical University and Social Science Research Centre in Berlin, the University of Groningen in the Netherlands and the Rand Corporation in California. In our view the program has important implications for Australia.

It has the potential to inform VET practice and further research, and therefore deserves the attention of the research community and the VET sector as a whole. We seek to give an overview of the program from an Australian perspective, that is, we concentrate on those aspects of the program which we see as having significance for this country. So, in spite of much of the research having dealt with details of the general and vocational education systems in a number of countries, these will not be discussed. Nor will we give the minutiae of individual enterprise investigations. Rather, we will attempt to extract the common themes and evaluate them in the context of this nation's industrial and educational circumstances.

Cullen (1997) in his report to the Australian National Training Authority, *Workskills and National Competitiveness: A Benchmarking Framework*, raises questions which he suggests provide a guide to examination of "benchmarks for competitive workskills in Australia". This paper goes some way to responding to those questions.

Inter-Country Differences

The impetus for the research was work carried out by Smith and Hitchens at the National Institute in the late 1970s using Census of Production figures. It revealed that, for two decades, output per German employee had been exceeding that per British employee. The gap was increasing, and by 1976 output of a German worker was fifty percent higher than a British one.

Research into a possible educational basis for the difference commenced with a comparison, by Sigmund Prais, of vocational qualifications of workers in Britain (1974-1978) and Germany (1978). The study, published in 1981, showed by industry sector as well as overall, that those categorised as having university qualifications or equivalent, constituted about the same percentage of the workforces in the two countries. But the proportions of the other two groups, those with no qualifications and those with qualifications at the non-professional or "intermediate" level to use Prais's term, were glaringly different (Table 1).

The approximate two to one ratio between those with no qualification and those with an intermediate qualification applied for all industry sectors other than professional and scientific services, in which case there was a two to one ratio between those with no qualifications and university graduates.

TABLE 1
Percentages of workers in Germany and Britain in the late 1970s with an "intermediate" qualification (see text) and no vocational qualification. (Source: Prais 1981)

	MANUFACTURING		NON-MANUFACTURING	
	INTERMEDIATE QUALIFICATION	NO QUALIFICATION	INTERMEDIATE QUALIFICATION	NO QUALIFICATION
GERMANY	60.8	35.7	59.4	31.6
BRITAIN	28.7	68.0	30.7	62.8

The program of research led by Prais, with a team of investigators, has continued through to the present. While they were concerned to test for a relationship between vocational education qualifications of workers and their levels of productivity, they recognised that it would be only weak evidence for a causal link, if not coupled with a plausible explanation of how differences in background are reflected in work practices and why these deliver different levels of productivity. They saw, too, that this would not be much help in the absence of soundly based recommendations for action in order to remedy implied deficiencies. It is these endeavours which have constituted the implicit objectives of the research program.

2. THE METHODOLOGY

At the outset it needs to be noted that training varies within countries in standards and content, and it has never been easy to arrive at a summary view of average differences between countries.

SJ Prais
Productivity, Education and Training:
An international perspective
National Institute of Economics and Social Research
Occasional Paper 48
1995, p. 15

Hypothesis

The research program initiated and led by Prais was designed to test the relationship between vocational education and enterprise productivity, where the latter is taken to mean units of output per time period per worker employed. The hypothesis was that initial, pre-employment vocational education is a major contributor to enterprise productivity, since it raises the skills of workers, and these are applied through more effective work practices.

Inter-Country Comparisons

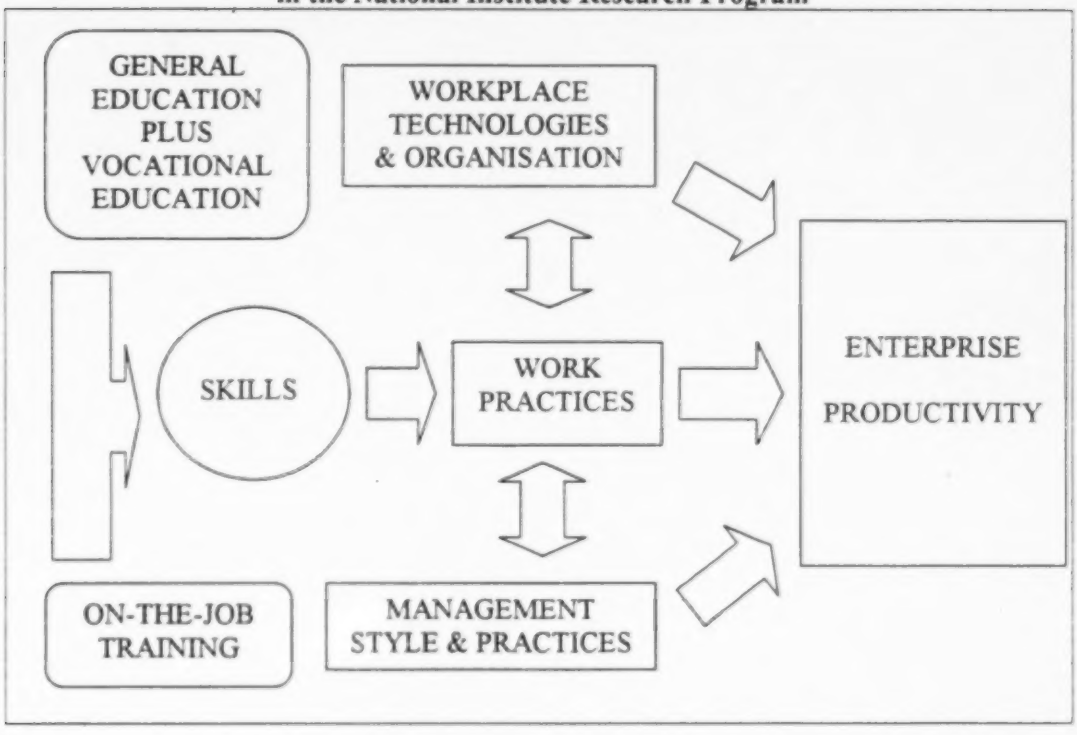
By adopting an inter-country comparisons approach, Prais and his colleagues, in a series of studies, each involving Britain and one or more other countries, identified establishments of similar size, each producing similar products, between which they could compare and contrast:

- worker productivity (units of output per unit time per person)
- management styles and practices
- technologies employed – plant, equipment, production processes etc.
- workplace organisation
- on-the-job training
- level and type of vocational qualifications of workers
- curriculum content relating to those qualifications.

Putative Model

We see the basic model representing their thinking as being depicted thus:

FIGURE 1
Putative Model of the Underlying Hypothesis in the National Institute Research Program



Enterprise productivity results from the interaction of people and technologies. The most effective work practices are ones which optimise the use of technologies and facilitate co-operative work relationships. Effective work practices depend on the intelligent and knowledgeable application of skills, which in turn depends on general education and vocational education. On-the-job training builds on and extends work-related knowledge and skills.

Matched Products

Selection of enterprises for detailed study has been a key issue. In order to compare like with like preference has been, as near as is practicable, for identical and therefore simple products. In this paper the National Institute's investigations on matched products will be referred to as the *core* studies. Some studies have examined paired enterprises on the basis of commonality of product type rather than a single product. Given constrained finances, sample size had to be kept small. Large enterprises were seen as easiest to deal with because they usually have assigned public relations personnel. But they were considered less likely to be dependent on multi-skilled workers. Nor, might we add, do they represent the trend in this era of more customised production. Prais and his colleagues settled on the middle range in size as being the most representative. A participation acceptance rate of about 50 percent was achieved. Any tendency for the

more successful to self-select was probably about the same in each country, so any distortions should have approximately cancelled out when looking at differences.

The core studies, and some others, involved observation in the workplace, and discussion with workers, management, and in some cases, suppliers. Productivity measurements were based on actual amounts of items produced and so avoided the problem of currency conversions. Comparisons have extended to include study of teaching techniques and assessment. In addition, Prais and colleagues have recently examined quality issues, having concluded that many supposedly identical products can, in reality, be differentiated on the basis of quality.

Daly et al (1985) acknowledged that the research team could have chosen to select on process as well as product, even to the point of specifying machine type. They did not as they considered that:

> *efficiency will be determined by technical factors, and the less likely we are to find differences in output rates and in manning requirements. Efficiency very often lies in choosing the right machines and the right materials to make a particular product.*

Core comparisons were mainly made between enterprises in Britain and Germany and, to a smaller extent, Britain and the Netherlands or France. The rationale has been that while productivity in those countries has typically exceeded that in Britain, the countries are culturally similar. By minimising cultural factor differences, it was felt that any recommendations for change would not be dismissed simply because they would be incompatible with the British way of life.

Supplementary Studies

Paired enterprise studies provided additional information on qualifications and work practices. National economic data provided further information on productivity, with respect to Germany, France, the USA and the Netherlands.

Comparisons using national economic sources depend on dealing with differences in currency and in the collecting and reporting of data. To explain: if an item made in country A, ex-factory and devoid of additional imposts, costs A$x, and essentially the same one made in country B costs B$y then A$x is equivalent to B$y in value terms for that item. But if the person hours which went into making it in A were double those that went into it in B then human productivity in A is only half that in B. This might be the result of much greater use of technology in B, but if the use of technology is similar then why is production in country A so inefficient? Some of the research has been concerned with improving techniques for making these calculations; the National Institute and the University of Groningen have explored approaches using different data sources. Probably the most meaningful have been comparisons of *net value added per employee* combined with *unit value ratios*, calculated on the basis of *ex-factory sale values* (which exclude taxes and duties). Van Ark's approach (1992) has recently been acknowledged as a "theoretically superior procedure" over traditional methods based on GDP price levels

(Harrigan 1997). Calculations simply relying on exchange rates have the potential to be misleading because exchange rates fail to reflect the varying relationships in value between different products and services.

Prais and colleagues have sought to use their core comparisons to inform thinking in relation to the broader comparisons, which similarly included, on occasions, visits to work-sites.

Industry Sub-Sectors

Core studies of matched products focused on:

- metal products – screws and nuts, springs, drills, valves, motor parts
- fitted kitchen furniture
- women's outer garments
- hotels - accommodation, mid-range large city
- biscuits - plain, fancy and elaborately fancy.

Studies of paired enterprises looked at:

- paper making
- information technology
- mechanical engineering
- electrical engineering
- paint and industrial coatings manufacture.

Broad studies included:

- building
- distribution, hotels and catering
- transport and communications
- finance and business services
- retail.

Education

In examining the implications for the education sector, the National Institute has variously turned to university-level education, vocational education and primary and secondary education. However, because the majority of the findings have related to vocational and school education, these have been the dominant concern of the research.

Magnitude of the Program

We estimate that since 1981 Prais and colleagues have published over thirty major papers (or "notes") with the National Institute Economic Review, and about twenty National Institute of Economic and Social Research discussion papers relating directly to the program. These figures are approximations because some papers are by colleagues who, at the time, were collaborating relatively distantly. In spite of the prodigious output it is

only in the last three or four years that the work has received what we believe to be a deserved level of citations from other sources.

3. FINDINGS

Differences in training matter. In a series of brilliant case studies S.J. Prais and his colleagues have shown clearly how higher skill levels on the Continent make possible quite different systems of work, involving much greater productivity.

R Layard, K Mayhew and G Owen
Britain's Training Deficit:
The Centre for Economic Performance Report
Ashgate Publishing, Aldershot
1994, p. 12

Terminology

In order to provide an overview of the work of Prais and colleagues, it is necessary to settle on some terms for referring to vocational education qualifications, given that they vary both country to country, and in their usage in the various papers produced as a result of the research program. Three terms will be used: *craft* for trade or equivalent qualifications, *master-craft* for post-trade supervisory type qualifications and *technician* for technical, paraprofessional qualifications.

Paired Product Findings

Table 2 summarises the results in relation to productivity and qualifications in the paired product comparisons (core studies). In every case the average productivity of the British enterprises fell well short of the average of their Continental counterparts. Similarly, the percentages of the British personnel holding intermediate qualifications were much lower. The results accorded with differences suggested by national data and strongly supported a positive relationship existing between worker productivity and vocational qualifications.

Work Practices

In comparing work practices between Britain and Germany, patterns emerged across sectors. German manufacturing was withdrawing from producing bulk quantities of standard goods. By contrast, large runs of basic-quality, identical products continued as the main business of British manufacturing.

Numerically controlled machinery was in use in both countries, but German companies were more inclined to exploit it to allow them to meet individual client requirements. Indeed, a revealing difference emerged in the meaning of *flexibility*. To German manufacturers it meant *the ability of the production process to deliver as required*; to British manufacturers it meant *the capacity to interrupt planned production to rush through a special job*. This difference in the importance of producing high quality products was discernible in German manufacturers' greater emphasis on the quality of their supplies, as typified by the higher quality steel used for metal products manufacture. The greater emphasis on the client was apparent too in meeting delivery dates -- it

appeared that they were always met by German manufacturers but were commonly not met by the British ones. German workers appeared to be able to perform a greater range of tasks and to move more easily between different functions than did the British, allowing production to be more customised.

TABLE 2
Productivity Levels Relative to Britain as 100, estimated through Micro Studies of Individual Enterprises. Figures are Mean Approximations or Ranges.

SUBJECT	GERMANY	OTHER	QUALIFICATIONS
Metal products Daly *et al* 1985 n=45	110 to 230 n'=20		Shopfloor: Britain 25%, Germany 50% craft level
	Range of productivity ratios on paired basis		Foreman: Britain 86% no qualification, Germany 100% craft level, 80% master craft level
Metal products Mason *et al* 1992 n=21		136 n'=9 Netherlands	Process workers: Britain 40%, Netherlands 80% craft level; Technical staff: Britain 45%, Netherlands 80% degree or technician level
Fitted kitchen furniture Steedman & Wagner 1987 n=17	230 n'=8 in machine-based processes		Shopfloor: Britain 0-10% craft-level, Germany 90% craft-level
Women's garments Steedman & Wagner 1989 n=22	200 n'=10		Machinists: Britain none with qualifications, Germany 80% craft
	Ratio for high quality only, Britain also making low quality		
Hotels Prais *et al* 1989 n=38	200 n'=24		Personnel: Britain 14% with qualifications, Germany 35% with qualifications
	Ratio of labour per guest night for equivalent standard. Means(Standard Deviation) 2.06(0.96),4.01(0.99)guest nights per employee		
Biscuits Mason *et al* 1994 n=29	140 n'=8	125 n'=5 Netherlands 120 n'=6 France	In process work, technical support and management: craft or above: Britain 25%, Germany 85%, Netherlands 65%, France 45%.
	Weight per person-hour, quality adjusted		

The total number of observations in each study is shown as n. The number for a particular country is shown an n'. The number of observations in Britain is equal to $n-\Sigma n'$.

The Netherlands too, exhibited much stronger client responsiveness, where plants were seen to be able to introduce improvements in product design in rapid response to customer feedback. Dutch machine operators, unlike the British ones, "could transfer from one task to another with less loss of time and wasted materials because of teething problems" (Mason *et al* 1992).

Another important difference was in the incidence of machine breakdowns; in Germany they were rare while in Britain they were common. For instance, in kitchen furniture manufacture, no breakdowns were observed in Germany though many were in Britain. While in some instances the Germans' machinery was newer, the reason for the difference in breakdowns appeared to be elsewhere; shopfloor workers in Germany carried out day to day cleaning and maintenance while their British counterparts did not. Prais and colleagues concluded that the difference resulted from the contrasting skills-levels, not from lesser time available for maintenance.

An additional complication reported to the investigators was the inclination of British shopfloor workers to "tinker" with machinery in an attempt to speed up throughput so as to gain bonuses. The result tended to be breakdowns rather than success! Mason *et al* (1994) put it this way:

> *As in other international comparisons carried out at the National Institute, the majority of British biscuit plants appeared to be trapped in a vicious circle with high levels of emergency maintenance militating against introduction of preventative maintenance procedures which might help reduce the incidence of breakdowns.*

The running speeds of equipment were much the same in the two countries, what were different were the attendance levels. These were significantly lower in Germany. This did not mean that personnel levels were always lower. Where a procedure demanded intensive human input this occurred. For instance, it was noted that clothing machinists in Germany, unlike in Britain, were able to handle delicate fabrics, allowing enterprises to manufacture for the top end of the market.

Core studies, which included the Netherlands and France, showed similar differences. Dutch plants, like those in Britain, experienced breakdowns, but only about half as many. Preventative maintenance was a much higher priority and Dutch machine operators had better diagnostic skills. Also, they could transfer more readily from one machine to another. French plants tended to deal with maintenance by having relatively large maintenance units.

While the core studies particularly emphasised the greater technological competence of workers on the Continent, this was not to the exclusion of all other qualities. For instance, Dutch employees appeared to be better motivated than their British counterparts and this was thought to be due to their vocational education having developed their skills and assisted them to clarify their ambitions.

The earlier core studies suggested the role of the master craft trained supervisor as especially important in German manufacturing's superiority. Later studies saw the role of the operator as equally important. Notwithstanding, the statement of one Stuttgart plant manager in relation to the collective responsibilities of the master craftsperson and the engineer is worth repeating (Daly *et al* 1985):

> *Three quarters of improvement in productivity are achieved through ensuring an adequate documentation of exact machine settings; of ensuring that all parts are available and of the right dimensions; that all*

drawings and measuring devices are available; that all involved know how to do their jobs; that the product design is appropriate; that the manufacturing and operation sheets are well prepared before work begins, and that no corrections will be necessary as production proceeds.

The one core study in the service sector, of hotels, found that while bed occupancy was about the same (54 and 57 percent in Britain and Germany respectively) there were highly statistically significant differences in the guest nights per employee. Michelin classified the hotels at the same level, so no obvious difference was expected in the degree of service. In Germany there were more labour-saving devices, more appropriate computer software in use, and better work organisation. While in both countries chambermaids lacked any formal qualifications, the German hotels placed greater emphasis on cleanliness.

Retailing

Jarvis and Prais (1989) also examined retailing by looking in particular, at vocational education for the sector in France and Britain. In common with Germany, France has provided extensive vocational education in retail, the difference being that in Germany learning in largely workplace-based while in France it has been mainly institution-based. Unlike the programs in Britain, courses in both the other countries have provided students with specialised product knowledge. While acknowledging the contribution to profitability which product knowledge can make in enterprises where client interaction and personal service are a feature, the authors questioned the amount of preparation provided – both in depth and in numbers of students, given the move away from retail customer service. It is interesting then to note that in 1995 Jarvis and Prais return to the issue in relation to quality. Retailing assistants' product knowledge both fosters higher tastes through better information provision to prospective customers and provides better feedback to manufacturers through skilled buyers. Thus German retailing was probably adding value to locally manufactured products in a way that British retailing was not. They conclude too, that German manufacturers' orientation to producing for the customised, high quality end of the market aligns with consumer taste in that country.

Productivity Levels using National Data

Broader studies of nationally collected data showed the pervasiveness of the advantage in productivity of other advanced western economies in the region over Britain (Table 3). During the 1980s Britain's productivity levels had improved relative to that of countries such as Germany, but they had not caught up. Comparing Table 4 to Table 1 it can be seen that those improvements were accompanied by a slight reduction in the percentage of unqualified personnel.

TABLE 3
Summary of Comparisons of Productivity using National Data, Britain equals 100.

	GERMANY	FRANCE	NETHERLANDS	USA
Buiding Prais and Steedman 1986		125		
Manufacturing Van Ark Feb. 1990a			140	
Manufacturing Van Ark Aug. 1990b		122		
Manufacturing O'Mahony 1992	120			
Manufacturing Van Ark 1992				170
Hotels and Catering O'Mahony, Oulton and Vass 1996	113	149		152
Transport and Communications *ibid.*	102	133		166
Financial Services and Real Estate *ibid.*	154	126		122

TABLE 4
Vocational Qualifications in the Workforce 1988 (Netherlands 1989), Percent.
(Source: Prais 1995)

QUALIFICATION	BRITAIN	FRANCE	GERMANY	NETHERLANDS
DEGREE	11	7	11	8
TECHNICIAN	7	7	7	19
CRAFT	18	33	56	38
NONE	64	53	26	35

Worker Capability

Certainly, the different productivity levels in the various sectors could not be explained as arising solely as a consequence of different technology; rather, the differences lay in the people – in the range of tasks performed and the way they were carried out. While the work that personnel performed was the result of management decisions, in both countries those decisions accorded with the capabilities of workers. But the capabilities seemed to be very different, which could be explained as a consequence of differences in work preparation. In Germany those capabilities appeared to be further enhanced by the presence of master crafts-qualified supervisors who were able to take detailed responsibility for production management tasks and liaise with technical support departments (Mason and Wagner 1994).

Recruitment

It would be reasonable to argue that the differences reflected recruitment decisions relating to the market segments enterprises chose to exploit. Hart and Shipman (c. 1991) looked at recruitment in paired enterprises in the two countries, in production, mechanical and electrical engineering, paper making and information technology, and found that Germany recruited rigidly on the basis of qualifications. Britain on the other hand expected that informal, on-the-job training would provide the skills needed. Both experienced shortages in skilled personnel – Germany in finding them and Britain in keeping them. Finegold and Soskice (1988) visualise Britain as "trapped in a low-skills equilibrium" where management practices, institutions and policy reinforce the *status quo*. Accordingly, recruitment practices and poor vocational education are both cause and effect, they cannot be viewed independently.

Sub-Sectors with High Levels of Uncertainty

The research program did not fail to explore an area in which Britain was known to enjoy productivity advantage. Mason and Wagner (1994) looked at the issue of "national systems of innovation", as a contribution to the debate about the internationalisation of innovation. They examined the chemicals industry sub-sector: paints and industrial coatings and specialised intermediates, an area in which Britain's productivity was known to exceed Germany's, and precision engineering, where Germany had superiority (Table 5).

TABLE 5
Percentages of Qualified Personnel in Two Industry Sub-Sectors, in Britain and Germany (Source: Mason and Wagner 1994)

FUNCTION AND QUALIFICATIONS	CHEMICALS (PAINTS etc)		PRECISION ENGINEERING	
	BRITAIN	GERMANY	BRITAIN	GERMANY
PRODUCTION Craft or higher	23	45	20	57
TECHNICAL SUPPORT Technician and graduate	65	55	55	55

For both these sub-sectors, Britain matched Germany in qualifications at the technical level, but not at the production level. The authors conclude that these are sectors were continuous research and innovation are essential, to meet the specialised expectations of clients. Thus they are ones in which there is a relatively high level of uncertainty, and in these circumstances productivity depends particularly on highly educated workers. Even so, in the chemicals sub-sector, where Britain out-performed Germany, the study suggests that it had a somewhat better qualified production workforce than it had in most other industry sectors.

The United States of America

Before claiming that their research conclusively supported the proposition that vocational education is a major contributor to enterprise productivity, Prais and colleagues needed to explain an apparent anomaly – the USA. As shown in Table 3, American productivity exceeded that of other counties in the majority of studies, in common with other research, which had shown its productivity to be the highest in the world. But it was also well known that post-school vocational education, in contrast to degrees, has constituted a relatively small component of the American education system. Mason and Finegold (1995) investigated precision engineering enterprises in the USA, Britain and the Netherlands. Production Census data had shown it to be an area where America enjoyed a significant productivity margin over both other countries.

The percentages of qualified personnel on the shopfloor as found in the study are shown in Table 6. Figures for the USA are shown as a range because there was large variation. Mason and Finegold found that the American enterprises were manufacturing *en masse* for a large, domestic market. While throughput rates were relatively high, enterprises were less efficient than Dutch plants and little different to British ones in tooling and adjusting production. They depended on the large pool of graduate engineers for their technical staff and on training of their more able workers. Many of their personnel were illiterate.

TABLE 6
Percentages of Shopfloor Workers with Vocational Qualifications in Production Engineering Establishments. (Source: Mason and Finegold 1995)

	USA	BRITAIN	NETHERLANDS
WITH QUALIFICATIONS	25-35	41	78
WITHOUT QUALIFICATIONS	65-75	59	22

Quality

Over time Prais and his colleagues started to suspect that matched products are not always as alike as was first thought. Attempting to match on the basis of product description may mislead because the descriptions fail to reflect quality measures. And using local advice on what is low, medium and high quality could also be misleading if notions of quality vary. This, indeed, proved to be the case and an item thought to be average quality in Germany was usually judged to be of high quality in Britain.

They saw that only by using a panel to compare products from each source could quality be estimated. Having done this they conclude (Jarvis and Prais, 1997):

> *Instead of approximately 24% higher manufacturing output per head in Germany, as previously derived from production Censuses, our estimates – though based on only a limited sample – suggest that the true German*

advantage over Britain in quality-adjusted output per head may well be some 50% higher today.

4. CONCLUSIONS

Research has shown that the main deficiency is at intermediate, and especially at craft levels, and it suggests that it would be inefficient to make up for this deficiency by over-providing higher level skills at technician or graduate level. We would add that the choice of national strategy involves social as well as economic values. It would be socially as well as economically damaging to neglect the training of the population at large.

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National Institute Economic Review
Volume 136 (May) 1991, p. 7

Demonstration of Relationship

The previous section gave an outline of the findings of Prais and colleagues when they tested the hypothesis, that vocational education is a major contributor to enterprise productivity, by raising workers' skills, which are applied through more effective work practices. They showed that high productivity levels amongst manufacturers in three European countries that have invested heavily in pre-employment, sub-professional, vocational education, equate with highly skilled work practices. Work practices in manufacturers of equivalent products in Britain, by contrast, were relatively unskilled, and productivity was lower. Furthermore, the difference appeared to extend to sectors other than manufacturing.

They claim that the relationship can be explained on the basis that the greater productivity is a consequence of enterprises being able to exploit the greater skills of workers through more skill-demanding work practices, and that the greater skills are a consequence of the different general and vocational educational backgrounds. They suggest that vocational education increases effectiveness by enabling workers to perform a wider range of related tasks, to be more client-responsive and better able to vary the work in accordance with client requirements, to operate equipment independently and to maintain it on a routine basis. In addition it enables supervisors to function more autonomously and play a strong leadership role. Importantly too, it may have contributed to German products being of a higher quality than their British equivalents.

Alternative Explanations

The research program has not been without its critics. Cutler (1992) implies that it appears to have been a program with a predetermined outcome, and judges that the relative technological sophistication and better management practices could equally have explained the observed differences. He considers also, that there was no evidence of a need for *en masse* vocational education as distinct from more selective training at the supervisor level. Chapman (1993, pp. 113-121) echoes some of Cutler's concerns. Shackleton (1995, p. 32) notes the impossibility of controlling for factors such as the age of equipment, and casts doubt on the focus on qualifications as a measure of work-related

learning. He suggests that the cause of the productivity differences might be elsewhere, such as in different managerial cultures.

Certainly, there have been sociological studies that suggest that cultural factors play a big part in determining workplace roles and relationships. Regini (1995) writes:

> *The predominance in a particular country or region of certain types of firm – and their associated patterns of human resource utilisation – not only in quantitative terms but from the point of view of their greater vitality and prosperity as well, is the outcome of long and complex processes rooted in their specific history.*

Köhler and Woodard (1997) see Germany having high-trust industrial relations which allow the complex tasks of planning, service and control to be given to production workers; but they also see German workers in particular, as having multiple skills which permit "a high degree of functional and task integration in production".

Having examined the published work in relation to the research program we consider that it has provided the strongest evidence yet for a causal link between vocational education and productivity.

Along with other research, it points to the need for synergy – of skills, attitudes, technologies, workplace culture etc. at all levels of an enterprise. So, inevitably, there could have been alternative explanations, but more skilled work along with better vocational preparation was the recurring pattern. The skills of personnel set limits on options. We see the research as underscoring that together, skilled management and skilled workers are able to optimise work practices.

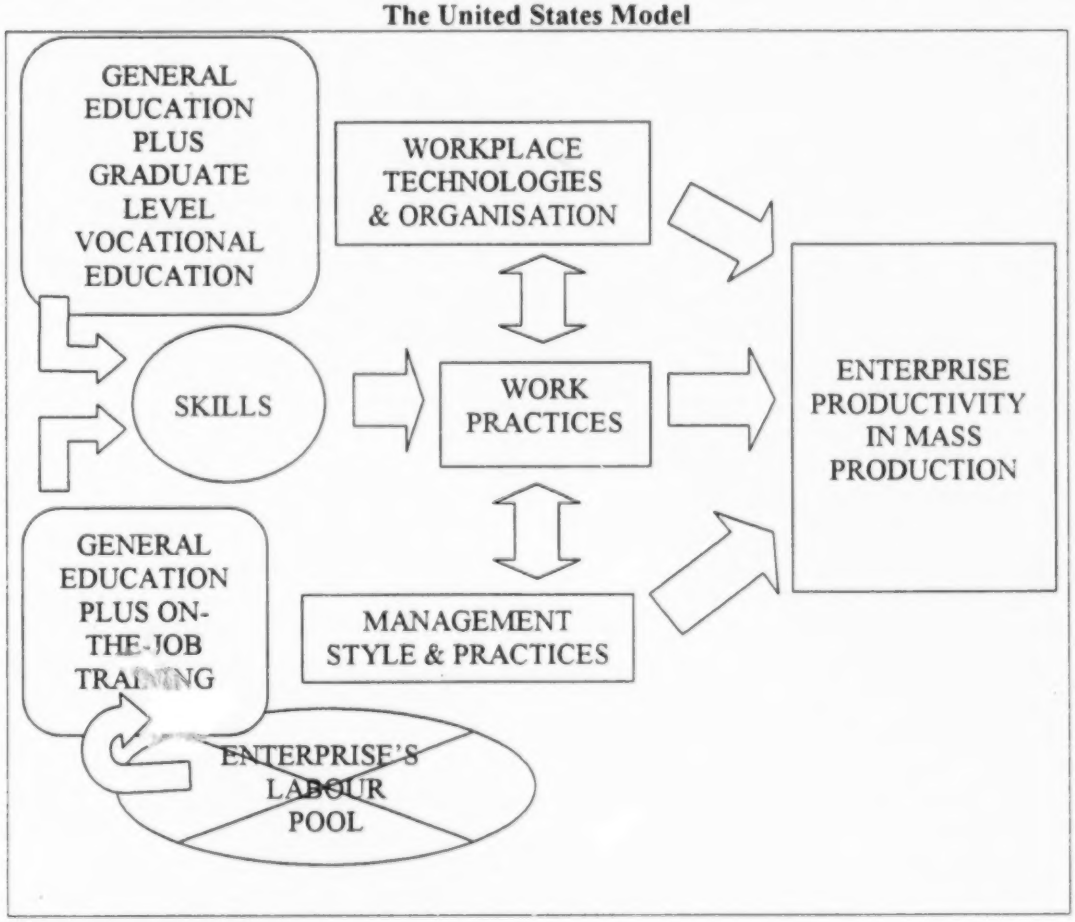
On the matter of differences in equipment age, while in some instances equipment was newer on the Continent, in others it was not. We of course agree that vocational qualifications are not synonymous with skills. Skills can be acquired informally, and even if gained through formal, on-the-job training or an institution, they might not be recognised in the form of a vocational qualification. But on-the-job training seldom delivers a broad array of transferable skills. Rather, it is usually brief and relatively specific. Where there are very large differences between two groups in the proportions with vocational qualifications, it would be highly improbable that there would be counterbalancing disparities in the proportions with unrecognised institution-acquired skills. Therefore, within the context of the research, we are confident that qualifications have served as a good indicator of broad, work-related skills.

Notwithstanding, there is a need to explain why the USA achieves high productivity levels in the absence of high levels of qualified personnel and therefore, presumably, skills. The findings in the USA suggest that manufacturers of mass produced items, in advanced economies, can at present be competitive in the absence of a strong system of up-front vocational education, if they operate in a very large domestic market, are somewhat protected from major sources of cheap labour (eg. by distance), use graduates as technical personnel and provide quality training for their most able employees.

The findings do not contradict vocational education being a major contributor to productivity, rather they suggest an alternative route. Given that it is hard to imagine any other country being in an equivalent position without major artificial barriers to imports, it is probably better to treat the USA as a special case, rather than to attempt to build it into the general model.

The American situation as elucidated in the study, we see being represented as in Figure 2. It is not intended to imply that vocational education has no place in the USA. Community Colleges are successfully delivering sub-baccalaureate vocational education which Grubb (1996) sees as providing students with substantial benefits, where the vocational education relates to their employment.

FIGURE 2
The United States Model



Advantages of the Paired Products Approach

If there is a problem with the National Institute's research program it is that there was only a small number of paired product studies. Yet all sectors of industry, and

government as well, have an interest in sound data on the impact of vocational education and training on productivity. The paired product approach, unlike other research methodologies, provides some capacity to control for many of the variables that potentially contribute to output. Results are fairly transparent and so are accessible to those not skilled in interpreting advanced mathematics. And because the methodology does not depend on national data collections, information provided by it can be relatively current. For all these reasons we see merit in utilising a similar approach to shed light on the way that skills are contributing to productivity in Australian enterprises. While acknowledging the extra difficulties, we hope to adapt the methodology so that we can look at service-delivering as well product-delivering sectors.

5. IMPLICATIONS

First, there is now a much greater awareness among the public at large of the importance of education and training issues, and the need for coherent policies for improvement. Secondly, concern with school has shifted to the acquisition of knowledge and skills – rather than the adequacy of resources or the social divisiveness of the system: there is a greater degree of understanding that the pursuit of happiness is not the over-riding objective at school, but that learning often needs effort and can sometimes be a painful process. Thirdly, there are signs of greater concern with economic objectives – a greater prevocational emphasis from the age of 14 at schools, and the need to improve vocational training and certification after the age of compulsory schooling.

SJ Prais
Keynes Lecture in Economics, October 1993
Economic Performance and Education:
The nature of Britain's deficiencies
Published as Discussion Paper No 52
National Institute of Economic and Social Research
October 1993

Educational Basis for Productivity Differences

Much of the National Institute program has been concerned with examining the educational features from which Germany in particular appears to have benefited relative to Britain. Based on those findings, Prais and colleagues have suggested that there are certain characteristics which Britain's general education and vocational education systems need to acquire if they are to be more effective in preparing people for work. These will be discussed in the context of the broader implications that efforts to increase the productivity of the Australian workforce might have.

Productivity and Employment

A study was undertaken by Australia's Economic Planning Advisory Commission (Hargreaves 1994), which looked at the consequences of a five percent increase in Australian labour productivity over five years. It employed a range of different economic models. While the predictions varied, depending on the models and assumptions they made, all but one suggested that increased labour productivity would lead, in the short term, to a reduction in employment through enterprise adjustment to maintain existing output, and all suggested, in the longer term, a period of increased employment as a consequence of a stronger economy. Of course, the study looked at what would happen if the country could produce the same output with less labour, or more of the existing product with the same input.

Mass Production or Customisation

Given both the smallness of Australia's domestic market and the proximity of large amounts of relatively cheap labour, the American route of mass production of

manufactured goods is clearly not a viable option. Lundberg and Wiker (1997) use the ratio of skilled labour content in exports relative to imports, as a measure of a country's accumulation of human capital. They conclude that, of OECD countries in 1985, Australia ranked with Greece, Spain and Turkey as a major skills-importer. While there has been improvement in the intervening period in Australian manufacturing, there is a continued reliance on high quality imports.

The National Institute research implies that an increase in productivity needs to involve a shift to increased quality as well as efficiency, and that this should be accompanied by strategies that engender quality consciousness amongst domestic consumers. This approach appears to constitute less of a threat to employment while also increasing the return on capital, because of its greater emphasis on import replacement.

Nevertheless, in advocating a greater emphasis on skilling to increase productivity, we acknowledge the potential short-term effect on employment; however, the alternative for those working in uncompetitive enterprises may be no employment at all! We acknowledge also that possession of skills does not mean that they will be used, unless decision-makers in enterprises are aware of and planning for the application of those skills – that is, skills should relate to the labour market. Crouch (1997) warns:

> *In the long run, it is possible and often likely that employers will notice the increased capacities among their workforce and start to make use of them in new activities: this is the assumption on which the whole of the up-skilling strategy rests. However the long-term might be very long, with considerable disillusion being experienced meanwhile among those who find that their increased education has served only to submit them to increased competition for jobs.*

Qualifications Profiles

A workforce that is currently equipped to achieve high productivity in customised, high quality products, would, on the basis of the National Institute research, have similarities in its qualifications profile to those of the Continental countries.

In Table 7 the composition of Australia's workforce is compared with those reported in the studies. Though Switzerland was not included in the paired product studies, it is tabulated because it will be discussed in relation to its general and vocational education systems.

The Australian figures are derived from Australian Bureau of Statistics data (McLennan 1996, p. 216). The source gives, *inter alia*, numbers of persons aged 15-64 years in employment together with their qualification type, for May 1995. The numbers of undergraduate diploma holders and associate diploma holders have been combined, as have been the numbers with skilled vocational and basic vocational qualifications. All those listed as without post-school qualifications have been treated as without vocational qualification. Clusters are categorised in equivalence to levels in the Australian Qualification Framework (AQF). Degree holders are shown as at AQF VI and above,

diplomates as at AQF IV and V, and other qualification holders as at AQF I-III. The figures given by Prais (1995) for technicians have been equated with ASF IV and V, and for craft with ASF 1-III.

Given that the Australian data in Table 7 are more recent than the European set, Table 8 is included to show that the percentage of the Australian workforce with post-school qualifications has increased very slightly, over a seven year period (*ibid.*, p. 212).

TABLE 7
Vocational Qualifications as a Percentage of the Workforce (Sources: see Text)

AQF EQUIVALENT	≥VI	IV/V	I-III	No post-school qualification
AUSTRALIA, employed persons, 1995	15	10	23	52
AUSTRALIA, plus unemployed persons 1995	14	10	22	54
SWITZERLAND 1991	11	9	57	23
GERMANY 1988	11	7	56	26
NETHERLANDS 1989	8	19	38	35
FRANCE 1988	7	7	33	53
BRITAIN 1989	11	7	18	64

TABLE 8
Percentages of Australians aged 15-64 with Post-school Qualifications (Source: see Text)

YEAR	1989	1990	1991	1992	1993	1994	1995
QUALIFICATIONS	39	40	41	41	39*	39	41

*The introduction of the ABSCQ in 1993 caused a break in the series.

It is apparent that the proportion of the Australian workforce with qualifications equivalent to AQF 4 and above compares favourably with the Continental countries. However, when the proportions with lower level skills and no qualifications are compared, the nation appears to fall somewhere between France and Britain. That is, Australia's disproportionately low number with lower level qualifications is offset predominantly by the number having no qualifications rather than the number having high qualifications.

Table 9 shows the qualifications-breakdown in Australia on an industry sector basis (*ibid.*, p. 217). Except for the education sector, the percentages without qualifications are higher than the overall proportions for Switzerland and Germany. Of these, all but health and community services, with its high level of professionals, have over a third of their workforces without qualifications.

TABLE 9
Percentages of Employed Persons aged 15-64,
Grouped by Industry (ANZSIC) and Qualification (Source: see Text)

AQF EQUIVALENT	≥VI	IV/V	I-III	No post-school qualifications
AGRICULTURE, FORESTRY & FISHING	4	8	19	69
MINING	10	8	34	48
MANUFACTURING	8	8	28	56
ELECTRICITY, GAS & WATER SUPPLY	15	14	32	39
CONSTRUCTION	4	7	45	44
WHOLESALE	10	10	25	55
RETAIL	5	5	20	70
HOSPITALITY	5	8	20	67
TRANSPORT & STORAGE	5	8	25	62
COMMUNICATIONS	7	20	26	47
FINANCE & INSURANCE	15	10	13	62
PROPERTY & BUSINESS SERVICES	26	13	19	42
GOVERNMENT ADMIN. & DEFENCE	24	10	17	49
EDUCATION	51	17	9	23
HEALTH & COMMUNITY SERVICES	29	19	18	34
CULTURAL & RECREATIONAL SERVICES	17	11	16	56
PERSONAL & OTHER SERVICES	9	11	31	49

Over the past decade Australia has drawn, in particular, on German and British experience in relation to vocational education and training. Some aspects of Australia's reforms, such as increasing workplace-based skills development and establishing a system of national qualifications, reflect that learning. It is our intention not to revisit what has already been learnt. Instead, the discussion will focus on reforms that Prais has advocated for British education, (particularly English which he sees as inferior to Scottish), and which have been given little attention so far in Australia, in the context of vocational education and training.

Technological Capability

Prais (1993) has concluded that English education has failed the less academic majority in developing technological capability and it is this deficiency which needs to be addressed both at school level and in vocational education. He condemns a school system that he claims devotes vast amounts of time to fanciful sketching of design concepts but which hardly ever has students prepare and read engineering-style drawings or construct items to precise measurements. In seeking to foster individual creativity the system has forgotten that initiative and novel ideas depend, for their full expression, on expert control of tools and media. And for people whose work is of a routine nature, skill in interpreting precise drawings and working to specified tolerances is fundamental.

Much of the evidence in support of the claims has been gathered through comparative studies of schools in Switzerland and England (Bierhoff and Prais 1993, 1995 and 1997). Switzerland was known to be similar to Germany in many respects, with a highly qualified workforce (see Table 7, above) and highly productive industry. Both workforces were educated in systems that employed a relatively traditional teacher-centred approach, a characteristic Prais concludes to be vital in educating for a technologically competent workforce. But recently, many primary schools in Germany adopted a more student-initiated experiential style of teaching. As a consequence, the National Institute research turned to Switzerland.

The Teaching of Mathematics

Prais (1997a) has stressed that much of initial teaching of mathematics should be a whole-class affair in which the teacher ensures that all pupils participate in doing mental calculations, thereby developing quantitative and problem-solving concepts. As evidence for the claim, Switzerland performed well compared to Britain and Germany in the Third International Mathematics and Science Study (TIMMS) undertaken in 1995 (Prais 1997b). Furthermore, an experiment to test the proposed methods was set up in the London Borough of Barking and Dagenham (Prais 1996) and is reported by two school inspectors to be proving successful in raising the mathematical ability of less academically able pupils (Luxton and Last 1997).

We believe the emphasis on assisting the less academic learner to be the most important message in the recently published work arising from the research program. Economically and ethically, Australia cannot afford to leave them behind. Australia, like Britain and the USA, is seeing most of its academically orientated young people entering degree level studies rather than sub-professional vocational education. Those who will be employed in positions requiring intermediate qualifications will seldom be the academically-high achievers. Table 10 lists the scores at the fifth, twenty-fifth and fiftieth percentiles in TIMMS gained in the group of students predominantly aged thirteen years in Australia and the countries included in the National Institute research program (see Lokan et al 1996).

TABLE 10

Percentile Estimates (± Standard Errors) of Student Achievement in the 13-14 Year-old Group in the Third International Mathematics and Science Study 1995

PERCENTILE	FIFTH*	TWENTY-FIFTH**	FIFTIETH
AUSTRALIA	372 ± 4 (88)	460 ± 2 (69)	529 ± 7
SWITZERLAND	401 ± 6 (84)	485 ± 2 (64)	549 ± 6
ENGLAND	361 ± 9 (82)	443 ± 5 (58)	501 ± 4
GERMANY	368 ± 8 (80)	448 ± 9 (58)	506 ± 6
FRANCE	415 ± 5 (69)	484 ± 1 (50)	534 ± 3
NETHERLANDS	397 ± 11(80)	477 ± 9 (66)	543 ± 9
USA	356 ± 4 (79)	435 ± 3 (59)	494 ± 6

*Figures in brackets are differences between the twenty-fifth and fifth percentiles.

**Figures in brackets are differences between fiftieth and twenty-fifth percentiles.

Prais contends that a long "tail" is evidence that an education system is failing the low achiever by not taking steps to assist him or her to keep pace, with the result that he or she will cognitively *drop out* with respect to numeracy. We therefore calculated the differences in the percentiles, as shown in the Table. It can be seen that, while the scores of the lower achieving half of the age cohort of Australians are about mid-range of the group listed, there is a relatively large spread. It must be acknowledged that different proportions of non-participation may be reducing the spread for some countries more than for others. Notwithstanding, the matter warrants further examination.

Student Assessment

In keeping with the need to develop technological competence, Prais (1991 and 1993) stresses the importance of rigorous assessment, if employers are to have confidence in the skills of those being granted vocational qualifications. He is convinced that written examinations must be employed along with practical testing. Practical tests alone cannot examine effectively for conceptual understanding, and are a grossly inefficient and costly way of testing for skills such as quantitative capability. We concur. There is a risk that current trends towards enterprise based assessment will be coupled, in many instances, with a total reliance on practice-based testing of routine tasks. Furthermore, there is the risk that the costs involved will result in inadequate assessment being undertaken, rather than cheaper and educationally valid methods being used. Indeed, written testing for some learning, makes holistic competency assessment in complex tasks more practicable.

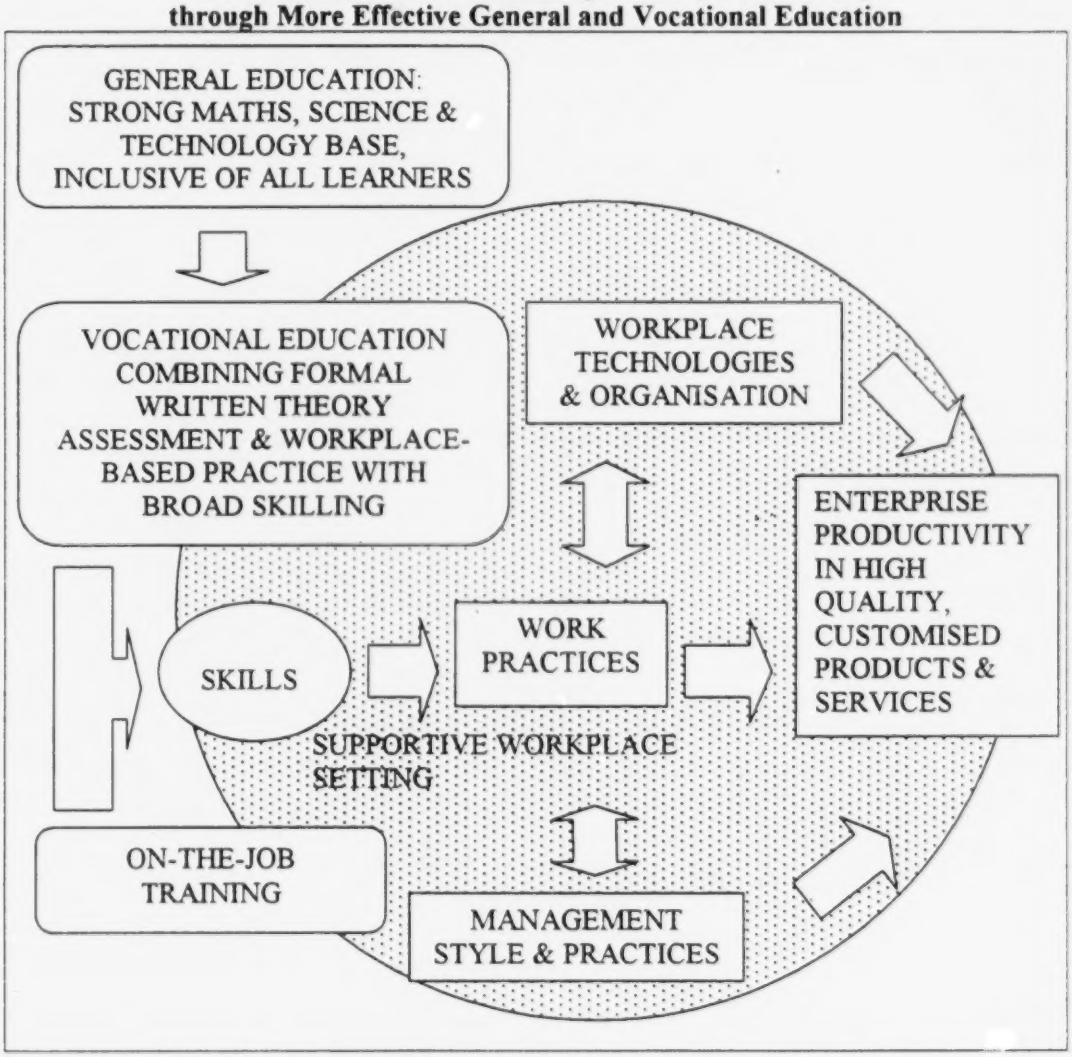
In seeing merit in many of the criticisms and suggestions for change that Prais has made on the basis of the research that the National Institute undertook, we are not endorsing "a return to basics". Rather, we infer that, in the pursuit of creativity, interpersonal skills, inter-cultural awareness etc., there has been a risk that cognitive and technological skills are not adequately developed. The research findings imply that they are vital to the country's economic future.

Some other recent studies have also examined the issue of the relationship between work practices and productivity. Black and Lynch (1997) in the USA studied three thousand manufacturing enterprises. They found that productivity levels depended, not just on particular work practices, but on how they were applied. Workers needed to be encouraged to think and interact to improve the production process; and the greater the proportion of workers who used a computer, the more productive the enterprise. Educational backgrounds did matter. In a large European study across industry, Kersley and Martin (1997) also conclude that communication in the workplace is causally linked to productivity increase. However, informal rather than formal communication appeared to be what mattered. Workers needed to be comfortable with initiating ideas and contributions, and the environment needed to be one that encouraged rather than demanded active participation. The studies complement and support the National Institute findings by emphasising that setting affects skills expression, interpersonal and technological.

Review of the Model

We now revisit the putative model (Figure 1) so that it reflects the findings and ideas we have discussed, and attempt to put it into a context consistent with Australia's circumstances (Figure 3). The model has a quality focus, consistent with the country's economic future depending, in part, on how well Australian-based enterprises can compete successfully, domestically and offshore, in the provision of high quality goods and services. For practicality's sake we make overt only those aspects of learning that have been the foci of the research.

FIGURE 3
A Possible Model for Increasing Industry Productivity through More Effective General and Vocational Education



The model recognises:

- the contribution of worker skills to the achievement of high productivity levels in good quality, customised products and services
- the importance of mathematics, science and technological studies in general education as a basis for vocational education and employment
- that both vocational education and on-the-job training may combine workplace-based and non-workplace-based learning
- that vocational education can be undertaken either pre-employment or concurrently with employment and may be undertaken many times throughout life because of occupational change
- the importance of broad skilling, and adequate assessment of underpinning knowledge and conceptual skills in vocational education
- the synergy of the workplace culture, the technologies employed, the practices that management chooses to effect, the style of communication and participation it promotes, and worker skills.

Cullen in his study on benchmarking (see above) lists questions which external benchmarking might address (1997, pp. 18-19). The findings in this research provide some response. They suggest that:

- there are links between qualifications profiles and competitiveness as measured by productivity levels between countries
- Australian workforce qualifications are not competitive with some European countries that have workforces able to achieve high productivity levels in high quality products
- a shift in the qualifications profile of the workforce as a result of a reduction in the proportion with no qualifications and an increase in the proportion with sub-professional qualifications would have the potential to benefit productivity
- enterprises (rather than industries) are at risk, that rely on production of *en masse*, low quality products
- competitiveness could be increased by increasing industry productivity, which in turn may be assisted by ensuring that all young people gain skills in and conceptual understanding of mathematics, science and technology.

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